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Report

Number: C009/07

Water sampling at the Berge Helene FPSO at Chinguetti field in Mauritania using passive samplers

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Commissioned by:	MRAG Ltd. 18 Queen Street W1J 5PN London United Kingdom
Project number:	3.46.12285.05

Number of copies:	10
Number of pages:	19
Number of tables:	10
Number of figures:	7
Number of annexes:	7

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Summary

Three rounds of water sampling were performed at the Berge Helene FPSO at the Chinguetti field in Mauritania using passive samplers attached to the FPSO to determine the levels of contamination that could potentially accumulate in organisms. Two rounds were carried out prior to the commencement of oil production (pre-PFW) and one following the start of produced formation water discharge (post-PFW).

Although water was sampled at 3-m and 10-m depths, bioaccumulation data were possible to report only for 3-m depth due to the repeatable loss of samplers deployed at 10-m depth. The reason for these losses remains un-known.

Retrieved passive samplers from each round were analysed for total bioaccumulative (petroleum) hydrocarbons, 9 phenols, benzene, toluene, ethylbenzene, xylene and 16 EPA polycyclic aromatic hydrocarbons. The accumulated amounts of chemicals during the two pre-PFW samplings were very similar and both of them can be considered to be representative for the pre-PFW phase. Surprisingly, the accumulated amount of chemicals during the post-PFW sampling round (*i.e.* after and during regular PFW discharges) was lower than in the pre-PFW sampling round. The most probable explanation is that drilling activities have stronger impact than the regular PFW discharges, but the possibility that the results were influenced by a variation in meteorological and hydrological conditions, such as ,e.g., direction and strength of the currents, could not be fully rejected.

The biomimetic nature of the Empore® disk extraction was used to estimate total body residues of chemicals in biota. These values were compared with critical body residues for three toxicological effects to evaluate baseline toxicity of the environment under the FPSO. Results showed that the total body residue levels in the aquatic environment under the FPSO are below the no-effect level for sub-lethal fish toxicity. However, in all measurements the levels exceed safe level for effects on ecosystem (HC_5): in pre-PFW sampling significantly, while in post-PFW only slightly. As these levels were observed directly at the source of possible contamination, the effects on the environment are likely to be substantially lower at increased distance from the FPSO.

1. Introduction

This document provides a report of three rounds of water sampling at the Berge Helene FPSO at the Chinguetti field in Mauritania using passive samplers attached to the FPSO. The goal of the passive sampling is to determine the levels of contamination originating from the FPSO that could potentially accumulate in organisms. The first and second sampling was conducted to collect baseline information prior to oil production, while the third sampling was conducted following first oil production and PFW discharge.

The sampling was conducted by IMARES' scientists. The first and the second sampling was performed by Dr. Heather Leslie and the third sampling by Mr. Evert van Barneveld.

The report covers the following:

- Sampler specification and sampling strategy
- Sampler preparation activities performed in the laboratory before sampling campaigns
- Transport of samplers to and from the FPSO
- Sampler deployment and activities offshore
- Results of sampling
- Results of analyses
- Interpretation of results

2. Methods and materials

2.1 Materials

C18 Empore® disks (C18 solid phase, 47 mm diameter, 90% ± 2% C18, 10% ± 2% Teflon fibers; carbon content of C18, 17%) used for passive sampling were purchased from Varian Inc (Middelburg, the Netherlands). Solvents n-hexane (purity >97.0%), acetone (purity >99.0%), methanol (purity >99.9%) and isooctane (picograde quality) were obtained from Promochem (Wesel, Germany) and Milli-Q water was prepared by purification of demineralised water using the Millipore-Q system. Performance reference compounds used (see Table 1) were purchased from Promochem. Liquid detergent Decon 90 was purchased from Fisher Scientific (Loughborough, UK) and Rogypal® AC-306 from Rogier Bosman Chemie BV (Heliningen, the Netherlands).

Table 1. List of performance reference compounds used

Compound	Approx. log Kow	Concentration in acetone (ng/ml)
D10-Acenaphtene	3.92-4.45	410
D10-Fluorene	4.18	380
D10-Phenanthrene	4.5	380
D10-Pyrene	not known	400
D6-Dimethylphtalate	1.53	370
D5-Simazine	2.18	380
D5-Atrazine	2.75	390
D12 Benzo(a)anthracene	5.61	1270
13C-Hexabromocyclododecane	5.56	100
HBCD (in Methanol)		

2.2 Sampler specification

The sampling device consisted of a disk holder, a transportation lid and a C18 Empore® disk as a receiving phase. The C18 Empore® disk consist of 10% Teflon matrix, in which 90% silica particles with chemically bonded C18 material ('octadecyl') are contained. Disk holders and transportation lids used in the first and second (pre-PFW) sampling were made of Teflon, while those used in the third (post-PFW) sampling were made of transparent polycarbonate (PC S75R). Different holders were used in the third sampling, because IMARES' stock of Teflon samplers was exhausted due to the losses in the first and second sampling and their production was terminated. The design of both types is shown in Figures 1 and 2. Both figures shows disassembled samplers – the disk holder and the transportation lid are shown in the upper part of the figures and the C18 Empore® disk lying on a yellow paper in the lower part of the figures. If sampler is assembled, the C18 Empore® disk is mounted into the disk holder and during transportation or storage (but not during exposure) is covered by the lid.

Figure 1. *Teflon sampler design (used in the first and second (pre-PFW) sampling campaign).*

Figure 2. *Polycarbonate sampler design (used in the third (post-PFW) sampling campaign).*

Three types of samplers can be recognized based on the purpose which they were prepared for:

1. Field exposure samplers - they were prepared to be deployed in the ocean and to be analysed for accumulated contaminants.

2. Fabrication blanks - the primary purpose of this type of QC sample was to account for any background contribution due to interferences from sampler components, and from contamination incurred during lab storage, processing, and analytical procedures. Moreover, these were essential for determination of the nominal performance reference compound level in the samplers prior to deployment. This type of QC consisted of individual samplers prepared as part of a batch for the field trial. These samplers however never left the laboratory and they were stored at 4˚C until the analysis of exposed samplers. Processing and analysis of fabrication blanks was concurrent and identical to that of deployed samplers.

3. Field blanks - they were used as QC samples for transport, deployment and retrieval. They account for potential contamination during sampler transport (to and from the field), and during exposure to site air while deploying and retrieving samplers. This type of QC consisted of individual samplers prepared as part of a batch for the field trial. They were taken to the field, were handled as the rest of the samplers of type 1 (including opening them at the field) but they were not deployed. Instead, the Empore disks were removed from the holder, transferred to the vials with milli-Q water and taken back to the laboratory. There they were stored at 4˚C whilst the field samplers were in the field and until their analysis together with exposed samplers.

In order to have a possibility to check samplers' performance during exposure, isotopically labelled compounds, called performance reference compounds (PRCs) were loaded into some of the passive samplers prior to field exposure. The PRC approach is based on the assumption that the effects of environmental variables (e.g. facial velocity-turbulance, temperature and biofouling) on the uptake rates of chemicals can be closely approximated by the effects on the release rate of PRCs, under the same environmental conditions. In other words, high concentrations of PRCs detected in the disc after exposure would indicate a poor exchange rate between water and disc and analytes' concentrations reported in such disc could then be excluded from the average calculation due to significant difference in uptake conditions. Ideally, PRCs should be present in all discs. However, their presence can hinder the determination of some of the analytes. Therefore, PRCs were not loaded to the discs meant for determination of polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs).

2.3 Preparation of the samplers

There were three sampling campaigns. The procedures applied to prepare the samplers for each of them are described here.

2.3.1 First sampling round

The sampling devices for the first sampling round used disk holders made of Teflon (Figure 1) and were prepared in the laboratory shortly before the sampler deployment.
Before sampler assembling, all Teflon parts of the sampler body were washed using a three-step procedure. First, samplers were soaked overnight in a 5 % aqueous solution of a liquid detergent Decon 90 and rinsed with Milli-Q water. Then, all parts were washed in acetone in an ultrasonic bath for 10 min. In the last step, all parts were washed in a dishwasher at 60°C.
C18 Empore® discs were first washed for 1 min in methanol and then they were soaked in methanol over night. The next day the discs were taken out of the bath, they were placed in a Petri dish in order to dry for a short period of time (not complete dryness). Then some of them

were spiked with the 100 µl of the D12-Benzo(a)anthracene solution, 500 µl of the HBCD solution and 250 µl of the solution containing the rest of the performance reference compounds (see Table 1). All the discs were then carefully mounted into the sampler body, covered by a layer of Milli-Q water, closed by a sampler lid, placed into a zip-lock plastic bag and stored in the refrigerator at +4°C until the transportation to the field. It was important that the C18 disks did not dry out between conditioning in methanol and deployment of the device. The samplers containing discs with PRCs were marked by the green tie. The number of samplers prepared and date of preparation is given in Table 2.

Table 2. Number of samplers prepared for the first sampling

Preparation of samplers accomplished on	17th January 2006
No. of field exposure samplers without PRCs	6
No. of field exposure samplers with PRCs	22
No. of fabrication blanks with PRCs	2
No. of field blanks with PRCs	2

2.3.2 Second sampling round

The sampler devices for the second sampling round were assembled on the FPSO in the day of deployment, because the Teflon holders (Figure 1) from the first sampling were re-used and they were retrieved just shortly before the deployment.
Preparation of the C18 Empore® disks was performed in the laboratory shortly before travelling to the FPSO for deployment according to the procedure used in the first sampling round (for the details, see above). After preparation, each disk was placed in a separate 10-ml vial filled with Milli-Q water leaving no headspace. Vials were then capped and stored at +4°C until their transport to the field. The number of discs prepared and date of preparation is given in Table 3.
Before assembling the sampling devices, all Teflon parts were thoroughly cleaned on the FPSO by brushing and using Milli-Q water and detergent Rogypal® AC-306. Then, the discs were taken out of the vials, carefully mounted into the sampler body and deployed. The samplers containing discs with PRCs were marked by the black ties.

Table 3. Number of samplers prepared for the second sampling

Preparation of discs accomplished on	3rd January 2006
No. of field exposure samplers without PRCs	12
No. of field exposure samplers with PRCs	14
No. of fabrication blanks with PRCs	3
No. of field blanks with PRCs	2

2.3.3 Third sampling round

The sampling devices for the third sampling round used disk holders made of polycarbonate (Figure 2) and were prepared in the laboratory shortly before the sampler deployment.

Before sampler assembling, all polycarbonate parts of the sampler body were rinsed by hexane and then ultrasonicated in hexane for 15 min. Then they were rinsed by methanol, ultrasonicated in methanol for 15 min and allowed to dry on lab air.

C18 Empore® disks were prepared by an improved method, which differs from those used in the previous rounds. The discs were first washed for 1 min in methanol and then soaked in methanol over night. After the discs were taken out of the bath, they were placed into filtration funnel and flushed with 10 ml of Milli-Q water. Performance reference compounds (PRCs) were loaded to some of the discs by filtration of 250 ml of spiked water through the discs. The spiked water was prepared in glass bottles by spiking 250 ml of Milli-Q water with 100 µl of the D12-Benzo(a)anthracene solution, 500 µl of the HBCD solution and 250 µl of the solution containing the rest of the performance reference compounds (see Table 1). Immediately after

all water was filtrated (avoiding dryness), the discs were removed from the funnel, carefully mounted into the sampler body, covered by the layer of Milli-Q water, closed by a sampler lid and placed into a zip-lock plastic bag. It was important that the C18 disks did not dry out between conditioning in methanol and deployment of the device. The samplers were stored at +4°C in the refrigerator until the transportation to the field. The samplers containing discs with PRCs were marked by the black tie. In the two previous sampling rounds only the field exposure samplers were prepared without PRCs, as can be seen from Tables 2 and 3. In this round, also fabrication blanks and field blanks were prepared without PRCs as an additional quality check of the sampling procedure. The number of samplers prepared and date of sampler preparation is given in Table 4.

Table 4. Number of samplers prepared for the third sampling

Preparation of discs accomplished on	28th July 2006
No. of field exposure samplers without PRCs	19
No. of field exposure samplers with PRCs	13
No. of fabrication blanks without PRCs	2
No. of fabrication blanks with PRCs	2
No. of field blanks without PRCs	2
No. of field blanks with PRCs	2

2.4 Transport of samplers for deployment

Samplers for the first and the third deployment and vials with the discs for the second deployment were transported in a cool box filled with icepacks to maintain temperature at about +4°C. The cool box was transported by plane and helicopter as the hand luggage of IMARES' scientist.

2.5 Sampler deployment

2.5.1 Place of deployment

Cages with passive samplers during each sampling campaign were attached to the stern of Berge Helene FPSO on its port side. The position is indicated in Figure 3. This place was selected because it was accessible by non-Woodside personnel and the possibility of interferences with traffic (e.g. patrol boat) and various cable and tube connections was minimal.

Figure 3. *FPSO Berge Helene at the Chinguetti field and indication of position where passive samplers were attached.*

2.5.2 Way of attachment

Samplers were attached to the side of the cage by metal wires as shown in Figure 4. Orientation of the samplers was such that the Empore® disks were facing inside the cages. The lids were kept on during all preparatory work and were removed from the samplers just before the cages were lowered into sea.

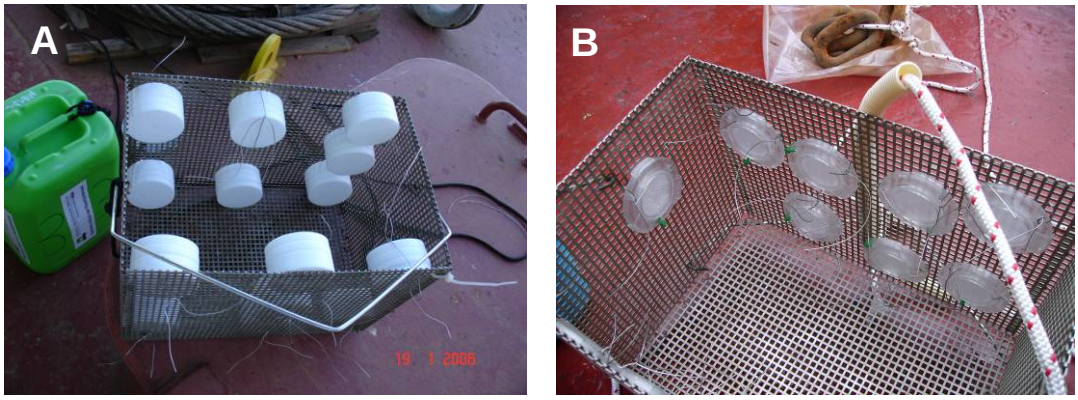

Figure 4. *Attachment of sampler devices to cages in the first (A) and the third (B) sampling campaign.*

Cages were attached to buoys and in turn, the buoys to the deck of FPSO by a rope (thickness 7 mm, white nylon with a red marker, extra strong, non-stretchable). To keep the cages at depth, 5-kg weights were attached to the cages. After the cages were lowered into water, they were tugged sharply several times to release any air bubbles in the passive samplers.
In the first sampling, two cages were deployed. One at the depth of 3 m and one at 10 m. Each cage was attached to its own buoy and the buoys were attached to the deck with a rope long enough to keep buoys in the water even if the FPSO was emptied and raised ca. 7 m.
In the second sampling, only one cage was used and it was deployed at 3 m water depth. The buoy was attached to the deck in the same way as in the first sampling round, i.e. using rope long enough to compensate for the rise and fall of the FPSO.
In the third sampling, two cages were deployed. One at 3-m and one at 10-m depth. Both cages were attached to one buoy by the same rope. Attachment of buoy to the FPSO was made by such length of rope that the cages were hanging from the deck and the buoy was just touching the sea. In other words, the buoy was used only to indicate the depth to which the rope should be lowered and to prevent deeper immersion of the cages. This way of attaching was selected to prevent the cages moving away from the FPSO and interfering with cables and oil-transport tubes. A company representative was instructed by IMARES scientist to check cages every day and if necessary to adjust the length of rope. Special attention was requested on the day when oil was to be unloaded from the FPSO (planned on Wednesday, 9th August) and the vessel would rises 7 m higher in the water than when fully loaded with oil.

Figure 5. *Preparatory work of IMARES' scientist on the FPSO before samplers' deployment*

Figure 6. *(A) Lowering the cage with passive samplers into sea during the first sampling campaign; (B) position of buoy with two cages during the third sampling campaign.*

2.5.3 Overview of exposure periods and samplers deployed

Exposure periods and overview of samplers deployed for all three sampling campaigns is given in Table 5.

Table 5. Overview of samplers deployed and exposure periods

Sampling campaign	Depth	Number of samplers deployed	Date of samplers'		Number of days in water
			deployment	retrieval	
1st (pre-PFW)	3 m	14	19.1. 2006	7.2. 2006	19
	10 m	14	19.1. 2006	7.2. 2006	19
2nd (pre-PFW)	3 m	15	7.2. 2006	18.2. 2006	11
3rd (post-PFW)	3 m	16	2.8. 2006	23.8. 2006	21
	10 m	16	2.8. 2006	23.8. 2006	21

2.6 Sampler retrieval

The Empore® disks were carefully removed from the sampler cases while still in the field. If suspended matter was present on the disc, it was wiped off with a tissue. Each disc was then placed in a separate 10-ml vial and filled with Milli-Q purified water leaving no headspace. The vials were capped and stored in the cool box filled with icepacks.

2.7 Transport of samplers to laboratory

Vials containing the retrieved discs were transported in the cool box filled with ice packs to maintain the temperature at about +4°C. The cool box from the first and second sampling was transported by helicopter and plane as a hand luggage of IMARES' scientist. The cool box from the third sampling was transported by helicopter as a hand luggage of IMARES' scientist and shipped from Nouakchott by courier.

2.8 Analysis

2.8.1 Total petroleum hydrocarbons (TPHs) and polycyclic aromatic hydrocarbons (PAHs)

Disks were transferred from the vial to a large glass tube. First they were extracted with 5 mL of acetone and then with 5 mL of hexane under sonification, in both cases for 5 min. The combined extract was then dried using sodium sulphate, concentrated to ca. 4 mL and split into 2 parts, one for TPH analysis (ca. 2 mL) and one for PAH analysis (ca. 2 mL).
Internal standards (decane (C10) and tetracosane (C40)) were added to the TPH part of the extract and the extract was concentrated under gentle stream of nitrogen to final volume of 0.5 mL. Agilent gas chromatograph (GC) with a flame ionization detector (FID) was used to analyse TPHs. The concentration was reported based on the total area found between elution times of decane (C10) and tetradecane (C40). Solutions of RIVM-oil (50; 100; 200; 500; 1000; 2000; 5000; 10000 µg/ml RIVM- oil in hexane) were used to prepare the calibration curve. Linearity observed was better than 0.9992 and the recoveries of RIVM-oil from disks were between 100 and 130%.
Acetonitrile (1 mL) was added to the PAH part of the extract, the extract was concentrated to a final volume of 1 mL under a gentle stream of nitrogen and analysed by high performance liquid chromatography with a fluorescence detector (HPLC-FLU). Solutions containing 16 EPA PAHs with concentration of 25, 50, 100, 150, 200 and 400 ng/ml in acetonitrile were used to prepare the calibration curve. Linearity observed was better than 0.9996 for all compounds and the recoveries from disks varied between 80 and 95%.
Since the recoveries were close to 100%, the results for exposed samplers were not corrected for recoveries but they were corrected only for field blanks.

2.8.2 Phenols

The disks were transferred from the vial to large glass tubes. First they were extracted with 5 mL of acetone and then with 5 ml of hexane under sonification, in both cases for 15 min. The combined extract was mixed with 60 mL of MilliQ water (pH 11-12) and 20 μL of D10-Anthracene as internal standard. For derivatization, potassium carbonate (0.5 g) and acetic acid anhydride (1 mL) were added. The extract was then shaken for 4 min and left to settle for 10 min. The organic layer was transferred to a glass test tube, evaporated under a gentle stream of nitrogen to a final volume of 1 mL and then transferred into a GC-vial. Phenols were measured using a gas chromatograph coupled to mass spectrometer (GC-MS). A calibration curve was prepared using the following concentrations of individual standards: 0.8, 2, 4, 8, 20, 40, 80, and 200 ng/g. The linearity was greater than 0.999 for all analytes. The recovery of individual phenols from the empore disks were between 59-77%. The results for samples were corrected both for recoveries and for field blanks.

2.8.3 Performance reference compounds (PRCs)

Extraction of performance reference compounds was performed together with extraction of phenols and they were measured in the same final extract (see section 2.8.2. for description of sample preparation). PRCs were measured in a separate run using a gas chromatograph coupled to mass spectrometer (GC-MS). Calibration curves were prepared using the following concentrations of individual standards: 0.8, 2, 4, 8, 20, 40, 80, and 200 ng/g. Linearity was greater than 0.999 for all analytes and recoveries from the empore disks were between 84 and 126%. Results for exposed samplers were corrected both for recoveries and for field blank.

2.8.4 Benzene, toluene, ethylbenzene, xylene (BTEX)

BTEX were extracted from the Empore disks by 8 mL of hexane in vials leaving minimal headspace. The temperature of the hexane used was between 0 and 3°C to minimize losses due to evaporation. Extraction was performed overnight while continuously shaking and in the refrigerator at temperatures between 0 and 3°C. After the disks were removed, 2 mL of extract was placed into 2-mL vials leaving no headspace and stored at 0°C. The analyses were performed by OMEGAM laboratories using gas chromatograph coupled to mass spectrometer (GC-MS).

2.8.5 Total molar amount of bioaccumulatable organic micropollutants

Total molar amount of bioaccumulatable organic micropollutants was calculated using chromatograms measured in analysis of total petroleum hydrocarbons. Similar to TPH analysis, the total molar amount was calculated based on the total area found between elution times of decane (C10) and tetradecane (C40), but instead of RIVM-oil calibration curve, tetradecane (C14) was used as an external standard. The molar response factor of tetradecane used for calculations was 4213895 nmol-1 and it was an average value of molar response factors calculated from injection of 0.04, 0.09, 0.13, 0.21, 0.25, 0.32 and 1.1 ng.

2.8.6 Calculation of analyte concentration on Empore disk ($C_{empore\ disk}$)

In order to estimate total body residues (residues of mixtures of chemicals) – which is done in Section 3.3 – the total molar concentration on the Empore® disk had to be calculated. The calculation procedure used is described here.
The total molar concentration on Empore® disk ($C_{empore\ disk}$) was calculated as a ratio of the total molar amount on Empore® disk and the volume of octadecyl hydrophobic phase in the Empore® disk. The volume of octadecyl hydrophobic phase in Empore® disk used is 136.8 μL and this volume was derived as follows: According to documentation obtained from the supplier, the Empore® disks consist of 10% w/w Teflon matrix, in which 90% w/w silica particles with chemically bonded C18 material ('octadecyl') are contained. This chemically

bonded octadecyl/silica material is claimed to have an organic carbon content of 17% w/w; implying that 1 g of the coated silica material contains 0.197 g of C18. If it is assumed that the density of C18 is equal to the density of octadecane, which is 0.78 g/mL, 1 g of Empore® disk contains 0.227 mL octadecyl hydrophobic phase. Consequently, 602.6 mg of Empore® disk contains 136.8 μL of octadecyl hydrophobic phase material.

3. Results and discussion

3.1 Sampling

An overview of the number of samplers both deployed and retrieved for both depths (3 and 10 m) and for all sampling campaigns is shown in Table 6 and the list of all samplers to be analysed with assigned LIMS numbers is given in Annex 6.

Table 6. Overview of number of samplers deployed and retrieved during each sampling campaign.

Sampling campaign	Depth	Number of samplers deployed	Number of samplers retrieved
1st (pre-PFW)	3 m	14	14
	10 m	14	0
2nd (pre-PFW)	3 m	15	7
3rd (post-PFW)	3 m	16	16
	10 m	16	0

In the first (pre-PFW) sampling round, two cages were deployed, each containing 14 samplers. One cage was placed at a depth of 3 m and one at 10 m. Samplers were deployed for 19 days. However, during this time the cages were taken out of water by FPSO personnel and placed for some time on the deck (probably due to installation work on the FPSO). After the exposure period, only the cage placed at 3-m depth could be retrieved, because the second cage was lost just prior to the arrival of IMARES' scientist to collect the samplers. The reason for the loss of the cage remains un-known.

Since there was serious concern that samplers from the first sampling got dry and lost their sampling capacity because they were placed on deck for a few days, repetition of the first sampling was agreed with Woodside. Deployment of the samplers for the second sampling round was planned during the trip to collect the samplers of the first sampling round. Due to the loss of one cage just prior to arrival, only one cage was available for re-use and consequently only one depth could be monitored. It was decided to monitor at 3 m and the samplers were exposed for 11 days. At the end of this exposure period, only 7 samplers out of 15 deployed could be retrieved, because the cage was found broken with only 7 samplers left. The cause for this damage is unknown.

In the third (post-PFW) sampling round, two cages were deployed, each containing 16 samplers. Similar to the first round, one cage was deployed at 3 m and one at 10 m. Samplers were exposed for 21 days. Having experienced difficulties from the previous rounds, precautionary measures were taken: FPSO personnel were asked to do daily check up on the samplers; thicker ropes were used to hang the cages; strengthened cages were used and cages were kept on short rope to keep them as close to FPSO as possible. Despite all precautions taken, only the cage from the 3 m depth could be retrieved. The bottom cage was lost a few days before retrieval. The reason for the loss of the cage remains un-known and is rather difficult to explain, because the rope was untouched. This means that the cage handle had to slip out of the rope after it was either broken or disconnected from the cage.

In conclusion to the sampling, enough samplers were retrieved from the 3-m depth to report bioaccumulation data for all three sampling campaigns. However, no samplers were retrieved from the 10-m depth in any of the sampling campaigns due to the loss of the cage in which the samplers were placed. Therefore, the following sections describe and discuss concentration and bioaccumulation data for 3-m only. Results of the first and second sampling campaign represent status of the pre-PFW phase (i.e. before production of oil and before any discharges of produced formation water), while the results of the third round describe the status of the post-PFW phase (after at least 1 month production and PFW discharging).

3.2 Comparison of accumulated amounts of priority pollutants in pre- and post- PFW samplings

Table 7 shows averaged amounts of TPHs, phenols, BTEX and PAHs found in disks from all three sampling campaigns. The values given in the table are averages of amounts measured in 2–6 disks, depending on the number of recovered samplers. The raw data used for calculation are shown in Annex 7.

Comparison of two pre-PFW samplings, *i.e.* comparison between first and second sampling, shows that the amounts of PAHs are very similar in both rounds, while amounts of TPHs and phenols are slightly lower in the second. Since the second round was performed as a repetition of the first sampling due to exposure of the samplers in the first sampling to air, the values of the second sampling are expected to be more representative. However, taking into account variation in the exposure and analytical measurement, the differences between the first and second rounds were rather small, and therefore both rounds can be considered to be representative of the pre-PFW-discharge period.

As Table 7 shows, BTEX were not detected in any of the samplings. The reason is that they are present in water in low concentrations due to their volatility (especially at sea temperatures in Mauritania) and the analytical method for detection of BTEX in passive samplers is unable to detect such low quantities. As for the phenols, accumulated amount of individual compounds in pre-PFW sampling varies between 0.2 and 60 ng per disk. The highest abundance in both pre-PFW samplings was detected for 2,5-dimethylphenol, 2,4,5-trichlorophenol and 2-methylphenol. As regards PAHs, in both pre-PFW samplings compounds with lower molecular mass are more abundant than those with higher molecular mass. The accumulated amounts of individual PAHs varies between <0.8 and 67 ng per disk and the most abundant compounds in both pre-PFW samplings are fluorene, phenanthrene, benzo(a)anthracene, chrysene and benzo(e)pyrene.

Comparison between pre- and post-PFW-discharge period shows that the levels of all measured compounds are significantly lower in post-PFW-discharge period. The majority of the compounds measured in the post-PFW sampling round are below or close to their limit of detections. This is rather un-expected observation. According to data of PFW discharge from the FPSO provided by Woodside there were no discharges of PFW during or before the pre-PFW rounds, but there were discharges every day for 3 months before post-PFW took place with average volume of 2500 m^3 per day. There are various possible explanations for this un-expected observation. The most probable one is that drilling activities, which might be accompanied by the random discharges or spills of drilling mud or oil, have stronger impact than the regular PFW discharges. Increased levels of 2-methylphenol, 2,5-dimethylphenols and 2,4,5-trichlorophenol in the first sampling supports this explanation. These compounds are used as components of lubricating oils, adhesives, paints and bactericide and are often present in drilling mud and marine paints. Another explanation might be that meteorological and hydrological conditions, such as direction and strength of the currents during post-PFW sampling could be different from those during the pre-PFW sampling and this variation could affect the up-take of chemicals into Empore® disks. In order to confirm one of the possibilities and to reject the other one, at least one additional post-PFW sampling round is recommended. If similar results are obtained, then it is likely that the drilling activities have stronger impact

than the regular PFW discharges and if higher levels are found, then the influence of variation in sampling conditions cannot be rejected.

Table 7. Comparison of average amounts of priority micropollutants found in disks from all three samplings

		Averaged amount (ng/disk) and RSD (%) in		
Compound group	Individual compounds	first sampling	second sampling	third sampling
TPH	TPHs	649 000 (73)	556 000 (53)	143 000 (17)
Phenols	2-methylphenol	17 (180)	4 (25)	1 (30)
	3-methylphenol	8 (77)	<8	0.4[a]
	4-methylphenol	<12	0.3[a]	<5
	2,5-dimethylphenol	60 (15)	15 (15)	<2
	2-chlorophenol	<2	<2	<2
	2,5-dichlorophenol	3 (88)	<4	<3
	2,4-dichlorophenol	4 (90)	0.2[a]	<3
	2,4,6-trichlorophenol	<0.8	<0.8	<0.8
	2,4,5-trichlorophenol	40 (130)	15 (57)	<0.8
BTEX	benzene	<70	<70	<70
	toluene	<80	<80	<80
	ethylbenzene	<80	<80	<80
	m/p-xylene	<80	<80	<80
	o-xylene	<210	<200	<200
PAHs	naphtalene	11 (57)	40 (70)	<1
	acenaphtene	7 (89)	10 (62)	<1
	fluorene	66 (63)	67 (51)	<0.5
	phenanthrene	23 (100)	33 (81)	<0.8
	anthracene	2 (42)	3 (69)	<1
	fluoranthene	5 (14)	6 (22)	<0.9
	pyrene	5 (71)	5 (74)	<0.8
	benzo(a)anthracene	21 (10)	13 (50)	<0.6
	chrysene	21 (24)	13 (73)	<0.4
	benzo(e)pyrene	25 (84)	24 (53)	<1
	benzo(b)fluoranthene	13 (93)	5 (16)	<5
	benzo(k)fluoranthene	<2	<2	<2
	benzo(a)pyrene	<0.8	<0.8	<0.8
	dibenzo(ah)anthracene	<7	<7	<7
	benzo(ghi)perylene	<3	<3	<3
	indeno(123cd)pyrene	<3	<3	<3

[a] averaged amount calculated from one value only

Whatever reason is behind the unexpected results of this comparison, it does not prevent us from toxicological interpretation of the measured data. This is given in the following section, in which total body residues are estimated and they are compared to critical body residues for baseline toxicity.

3.3 Estimating total body residues and baseline toxicity

Risk assessment based on a single chemical approach is often not sufficient because polluted sites usually contain complex mixtures of sometimes hundreds of different compounds. This is especially true if narcosis or baseline toxicity is considered, because there are many compounds with narcosis toxicity and the effects of narcosis-type chemicals are well known to be completely concentration additive (Koneman 1981, Broderius 1985, Broderius 1995, Hermens 1985). Therefore, for assessment of baseline toxicity it is relevant to estimate body residues of mixtures of chemicals (*i.e.* total body residue (TBR)).
The Empore® disk extraction performed in sea water under the FPSO is a biomimetic extraction, in which a chemical is extracted from the aqueous phase in a hydrophobicity-dependent manner. In other words, more hydrophobic compounds are extracted more efficiently than are less hydrophobic compounds, similar to the bioconcentration process in biota. Therefore, the measured total molar concentration on the Empore® disk ($\Sigma C_{empore\ disk}$) can be used to estimate the total body residue (TBR_{est}) of chemical(s) in biota. This can be done by using equation

$$TBR_{est} = 0.198 \Sigma C_{empore\ disk},$$

which was derived by Verhaar (1995) for a heterogeneous set of non-ionic compounds and was based on the assumption that bioconcentration factors of non-polar organic chemicals are linearly related to octanol-water partition coefficient (K_{ow}) and on a linear relationship between partition coefficient onto the Empore disk and K_{ow} as established by Verhaar (1995).
The total molar concentration on the Empore® disk ($\Sigma C_{empore\ disk}$) was calculated using chromatograms of total petroleum hydrocarbons and using the molar response factor of tetradecane (for details, see section 2.8.6). Values of estimated total body residue for disks from all three sampling campaigns are given in Table 9.

Table 9. Estimated total body residue of bioaccumulatable organic micropollutants

Sampling campaign	Disk' LIMS number	TBR_{est} (mmol/L lipid)
I (pre-PFW)	2006/848	1.097
	2006/849	2.358
II (pre-PFW)	2006/868	1.859
	2006/869	0.699
	2006/870	2.754
III (post-PFW)	2006/823	0.567
	2006/815	0.423
	2006/816	0.419
	2006/617	0.366
	2006/818	0.407
	2006/819	0.592
	2006/820	0.354

The TBR_{est} parameter is a screening tool for the total bioaccumulation of organic chemicals in biota. Clearly, this is relevant information but bioaccumulation is not a toxicologic endpoint. The measured values for TBR_{est} can be compared with critical body residues for baseline toxicity. The concept of critical body residues (CBR) was introduced by McCarty () and has been applied in several other studies (McCarty 1991, McCarty 1993, Hoogen 1988, Wolf 1992, Wezel 1995). It was shown that for sets of compounds exhibiting baseline toxicity there is a fixed lipid-normalized whole-body concentration at which aquatic animals die, the so-called critical body residues. McCarty (1991) reported a lipid-normalized CBR for baseline toxicity chemicals of ca. 50 mmol/L; Leeuwen (1992) and Verhaar (1994) used this CBR approach to arrive at a safe body residue, based on aquatic HC_5 values (hazardous concentration to 5% of all species), of

ca. 0.25 mmol/L. An overview of critical body residue levels for baseline toxicity at a few well-known effects are given in Table 10.

Table 10. Overview of critical body residue levels in fish for three different effects

Endpoint	Concentration (mmol/L lipids)	Reference
50 % lethality – fish	50	Verhaar 1995, McCarty 1991
No-observed-effect (NOEC) – fish	5	Verhaar 1995
Tentative safe level for ecosystem effects (HC_5)	0.25	Verhaar 1995, Leeuwen 1992, Verhaar 1994

The comparison of measured values for TBR_{est} with critical body residues for baseline-type toxicity given in Table 10 is shown in Figure 7 where, in addition to the TBR_{est} values, no-effect body burdens for two endpoints are given. The figure clearly shows that all levels are below the no-effect level for sublethal fish toxicity, although some disks from the first and second sampling shows levels close to this level. Although there is an apparent decrease in levels for the third (post-PFW) sampling, no level is below the safe level for ecosystem effects (0.25 mmol/L).

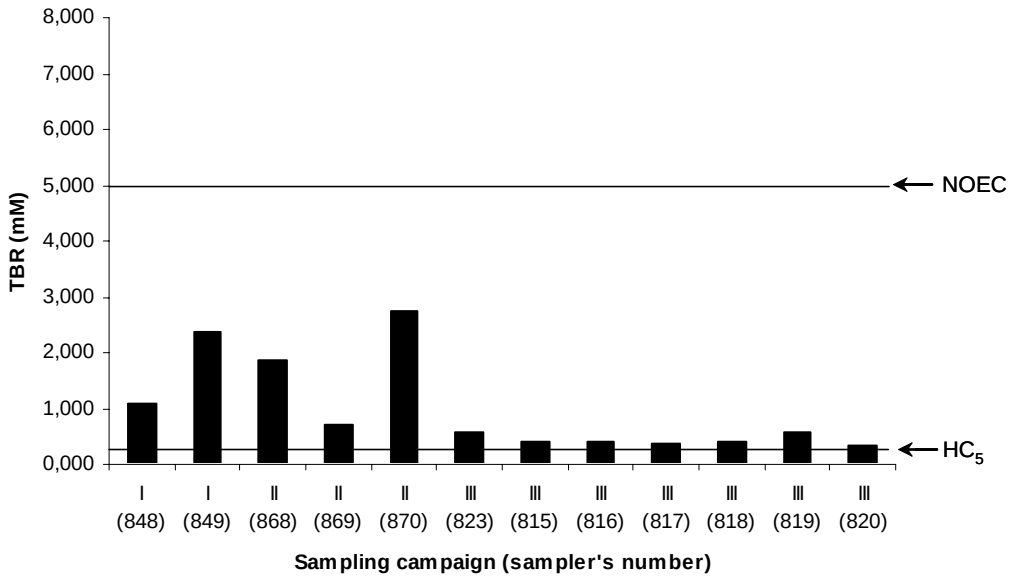

Figure 7. *Estimated total body residues (TBR_{est}) of sea water in the depth of 3m under FPSO for pre-PFW (campaign I and II) and post-PFW (campaign III) period.*

Although the comparison of measured TBR_{est} with critical body residues is rather positive, one should not forget that the assumption that all chemicals only have baseline toxicity is often not valid. In many cases, chemicals with more specific modes of action are present. Aqueous effect concentrations or effect body residues of such compounds are usually much lower than those for baseline toxicity chemicals. On the other hand, if the actual aqueous concentration or body residue of a chemical with a specific mode of action is below the effect level for specific toxicity, this same chemical will still contribute to the overall baseline toxicity. If many chemicals are present, these small contributions may lead to a relatively high contribution to the overall baseline toxicity because baseline toxicity is completely additive.

4. Conclusions and recommendations

Three sampling campaigns were performed. Enough samplers were retrieved from the 3-m depth to report bioaccumulation data for all three sampling campaigns. However, no samplers were retrieved from the 10-m depth in any of the sampling campaigns due to the loss of the cage in which the samplers were placed. Consequently, the bioaccumulation data were reported only for the depth of 3 m. The reason for loss of cages at 10-m depth remains unknown. In order to increase the probability of samplers' retrieval in future sampling campaigns, it is recommended that bulk of samplers deployed are split and placed into more cages.

The accumulated amounts of chemicals during the two pre-PFW samplings were very similar and both of them can be considered to be representative for the pre-PFW phase. Surprisingly, the accumulated amount of chemicals during the post-PFW sampling round (*i.e.* after and during regular PFW discharges) was lower than in the pre-PFW sampling round. The most probable explanation is that drilling activities have stronger impact than the regular PFW discharges. Increased levels of 2-methylphenol, 2,5-dimethylphenols and 2,4,5-trichlorophenol in the first sampling round supports this explanation, because these compounds are used as components of lubricating oils, adhesives, paints and bactericide and are often present in drilling mud and marine paints. However, to fully reject the possibility that the difference between the pre- and post-PFW results was influenced by a variation in meteorological and hydrological conditions, such as direction and strength of the currents, at least one additional post-PFW sampling round is strongly recommended.

The biomimetic nature of the Empore® disk extraction was used to estimate total body residues of chemicals in biota. These values were compared with critical body residues for three toxicological effects to evaluate baseline toxicity of the environment under the FPSO. Results showed that the total body residue levels in the aquatic environment under the FPSO are below the no-effect level for sub-lethal fish toxicity. However, in all measurements the levels exceed safe level for effects on ecosystem (HC_5): in pre-PFW sampling significantly, while in post-PFW only slightly. As these levels were observed directly at the source of possible contamination, the effects on the environment are likely to be substantially lower at increased distance from the FPSO. The sampling of *Sardinella aurita* was simultaneously directed to monitor these "long distance" effects of the FPSO on the ecosystem (IMARES 2007).

Passive sampling is very efficient tool for monitoring of water environment at the FPSO and, therefore, continuation of the passive sampling on a regular basis can be recommended. Such a monitoring will provide data on development of water quality with time.

Although the passive sampling provides an excellent data on water quality during the exposure of the samplers and, if performed regularly, also on development of water quality with time, it does not provide any information on accumulation of contaminants in environment over the years of oil production. Therefore, a long term annual monitoring programme of biota should be established. The species of interest is *Sardinella aurita* as a representative of pelagic fish and for which levels before and shortly after PFW discharges were acquired in the parallel study (IMARES 2007). In addition, the monitoring programme should be extended to benthic fish species and invertebrates such as mussels, cockles or octopus, because these species do not migrate, they live close to the sea bottom (which might be affected by long term discharges) and they are important for Mauritanian fisheries industry and for the local population.

5. References

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W. van der Galiën

Signature: _____

Date: 25 January 2007

Annexes 1–7

Annex 1. Fieldwork diary – deployment of passive samplers for the first sampling campaign (Dr. Heather Leslie)

Wednesday, 18th January 2006 (day 1)
06:50 – 08:05 - Amsterdam - Paris (Flight AF 8227)
10:45 – 15:15 - Paris - Nouakchott (Flight AF 0764)
Accommodation in Woodside campus

Thursday, 19th January 2006 (day 2)
10:00 – 11:00 - Transport to FPSO by helicopter
11:00 – 17:00 - Samples were prepared, proper place was selected and samplers were placed into the water
17:00 – 18:00 - Transport to Nouakchott by helicopter
23:45 – 24:00 - Nouakchott - Paris (Flight AF 765)

Friday, 20th January 2006 (day 3)
00:00 – 05:55 - Nouakchott - Paris (Flight AF 765)
06:45 – 08:05 - Paris - Amsterdam (Flight AF 1140)

Annex 2. Fieldwork diary – retrieval of passive samplers from the first sampling campaign and deployment of the new ones for the second campaign (Dr. Heather Leslie)

Monday, 6th February 2006 (day 1)
06:50 – 08:05 - Amsterdam - Paris (Flight AF 8227)
10:45 – 15:15 - Paris - Nouakchott (Flight AF 0764)
Accommodation in Woodside campus

Tuesday, 7th February 2006 (day 2)
10:00– 11:00 - Transport to FPSO by helicopter
11:00 – 17:00 - Samplers were taken out of the sea. The bottom cage containing 14 samplers was lost. The samplers from the upper cage were transferred into the vials with MiliQ water and transported to IMARES. During the discussion with the crew was discovered that the cage was on the deck for at least few days. This definitely influenced the measurement and the experiment should be repeated. Recovered cage with 14 new samplers was therefore placed again in the depth of 3 m.
17:00 – 18:00 - Transport to Nouakchott by helicopter
23:45 – 24:00 - Nouakchott - Paris (Flight AF 765)

Wednesday, 8th January 2006 (day 3)
00:00 – 05:55 - Nouakchott - Paris (Flight AF 765)
06:45 – 08:05 - Paris - Amsterdam (Flight AF 1140)

Annex 3. Fieldwork diary – retrieval of passive samplers for the second sampling campaign (Dr. Heather Leslie)

Friday, 17th February 2006 (day 1)
06:50 – 08:05 - Amsterdam - Paris (Flight KL 1227)
10:45 – 15:15 - Paris - Nouakchott (Flight AF 0764)
Accommodation in Woodside campus

Saturday, 18th February 2006 (day 2)
10:00 – 11:00 - Transport to FPSO by helicopter
11:00 – 17:00 - Samples were taken out of the sea
17:00 – 18:00 - Transport to Nouakchott by helicopter
23:45 – 24:00 - Nouakchott - Paris (Flight AF 765)

Sunday, 19th February 2006 (day 3)
00:00 – 05:55 - Nouakchott - Paris (Flight AF 765)
07:20 – 08:40 - Paris - Amsterdam (Flight AF 1240)

Annex 4. Fieldwork diary – deployment of the passive samplers for the third sampling campaign, PFW sampling for arsenic analysis and investigation of the PFW system (Mr. Evert van Barneveld)

Monday, 31st July 2006 (day 1)
08:05 – 09:25 - Amsterdam - Paris (Flight AF 8229)
10:40 – 14:10 - Paris - Nouakchott (Flight AF 0764)
After the arrival, Evert was transported to Woodside campus where he had a meeting with Tanya Bonnici. They discussed the additional work he was requested to do on the FPSO: PFW sampling for arsenic analysis and obtaining an understanding of how the waste water system, and hence production and transport of PFW onboard the FPSO works.

Tuesday, 1st August 2006 (day 2)
Early in the afternoon, Evert was transported to the FPSO by helicopter. Since the permit to work on the FPSO was issued after 19:00, there was no time left to place the passive samplers on this day.

Wednesday, 2nd August 2006 (day 3)
In the morning, passive samplers were placed into water. The cages were attached to the stern on the portside. This is the only place where they could be attached because of possible interferences with all kind of cables in other places. Such length of rope was used to attach the cages that they were hanging from the stern and they were not hanging on the buoys. The buoys were just touching the sea and were used to indicate the depth and prevent deeper immersing. This way of attaching was selected to avoid that the cages are moved away from the FPSO and interfere with other cables and oil-transport tubes. Evert instructed Steinar to check the cages every day and if necessary to adjust the length of the rope. Special attention was requested to be paid on the day when oil is unloaded from the FPSO (planned on Wednesday August 9th) and the vessel will rise about 8 meters.
In the afternoon, Evert discussed with Steinar and Jemal the waste water system and treatment and transport processes of PFW. Later in the afternoon, Steinar took Evert to see the online detector for analysis of oil in the PFW which is located at the bottom of the FPSO, about 30 meters below the 1st deck.

Thursday, 3rd August 2006 (day 4)
Long discussion with the chief officer, David, about internal processes related to PFW and its discharges. Later in the afternoon, samples of PFW were taken for arsenic analysis from the valve just before the online analyser. Samples of crude oil were organized with David.

Friday, 4th August 2006 (day 5)
Early in the afternoon, Evert was transported by helicopter back to Nouakchott. He carried with him samples of PFW for arsenic analysis. The samples were placed in the cool-box together with ice-packs to keep them at 4-8ºC. The glass bottles with crude oil were not allowed on the helicopter. It was arranged that they will be send ashore to Tanya Bonnici by the supply vessel and then they will be shipped to IMARES.
During dinner, Evert provided Tanya with all information he obtained on the FPSO.
22:55 – 24:00 - Nouakchott - Paris (Flight AF 0765)

Saturday, 5th August 2006 (day 6)
00:00 – 06:05 - Nouakchott - Paris (Flight AF 0765)
07:20 – 08:40 - Paris - Amsterdam (Flight AF 1240)

Annex 5. Fieldwork diary – retrieval of passive samplers for the third sampling campaign, PFW sampling for chemical characterization and ecotox study (Mr. Evert van Barneveld)

Monday, 21st August 2006 (day 1)
06:50 – 08:05 - Amsterdam - Paris (Flight AF 2341)
10:40 – 14:10 - Paris - Nouakchott (Flight AF 0764)
After the arrival, I was transported to Woodside campus where he had a meeting with Haiba, to be sure the samples were transported correctly.

Tuesday, 22nd August 2006 (day 2)
Early in the afternoon, I was transported to the FPSO by helicopter. Since the permit to work on the FPSO was issued after 19:00, there was no time left to collect the passive samplers on this day.

Wednesday, 23rd August 2006 (day 3)
In the morning, the passive samplers were collected from the water. The cage which was on 10 meter depth was gone. From my point of view that was impossible because the rope was still intact, so something (maybe a big fish like a shark) could have taken it. The cage which was on 3 meters depth was intact and the samples were collected and stored in vials with Milli-Q water.
In the afternoon, Evert discussed with Bob Reed when and how the water samples should be taken.

Thursday, 24th August 2006 (day 4)
The chief officer took care of the water sampling together with Evert. All water samples were taken at the same time (filling bottles one by one) from the valve just after the automatic oil detector. It was not possible to take water samples at different times, because Evert had to be always accompanied by somebody from Woodside personnel. Samples of crude oil were organized with the chief officer.

Friday, 25th August 2006 (day 5)
Early in the morning the oil and water samples were shipped out on The Pacific Warrior, they transported the samples to the Thor Pioneer. Haiba took care of transporting the samples of water and oil to The Netherlands. Evert was transported by helicopter back to Nouakchott. He carried with him samplers. The samplers were placed in the cool-box together with ice-packs to keep them at 4-8ºC. The Samplers were transported by DHL to Holland.
22:55 – 24:00 - Nouakchott - Paris (Flight AF 0765)

Saturday, 26th August 2006 (day 6)
00:00 – 06:05 - Nouakchott - Paris (Flight AF 0765)
08:00 – 09:20 - Paris - Amsterdam (Flight AF 1340)

Annex 6. List of samplers to be analysed

Sampling	Sample description	LIMS code
1st sampling	Serie 1, 3m, Disk 1, No PRC's	2006/0847
	Serie 1, 3m, Disk 2, No PRC's	2006/0848
	Serie 1, 3m, Disk 3, No PRC's	2006/0849
	Serie 1, 3m, Disk 4, With PRC's	2006/0850
	Serie 1, 3m, Disk 5, With PRC's	2006/0851
	Serie 1, 3m, Disk 6, With PRC's	2006/0852
	Serie 1, 3m, Disk 7, With PRC's	2006/0853
	Serie 1, 3m, Disk 8, With PRC's	2006/0854
	Serie 1, 3m, Disk 9, With PRC's	2006/0855
	Serie 1, 3m, Disk 10, With PRC's	2006/0856
	Serie 1, 3m, Disk 11, With PRC's	2006/0857
	Serie 1, 3m, Disk 12, With PRC's	2006/0858
	Serie 1, 3m, Disk 13, With PRC's	2006/0859
	Serie 1, 3m, Disk 14, With PRC's	2006/0860
	Serie 1, Lab blanco, Disc 31, With PRCs	2006/0861
	Serie 1, Lab blanco, Disc 32, With PRCs	2006/0862
	Serie 1, field blanco, With PRCs	–
	Serie 1, field blanco, With PRCs	–
2nd sampling	Serie 2, field blank, Disk 1, With PRCs	2006/0863
	Serie 2, field blank, Disk 2, With PRCs	2006/0864
	Serie 2, lab blank, Disk 1, With PRCs	2006/0865
	Serie 2, lab blank, Disk 2, With PRCs	2006/0866
	Serie 2, lab blank, Disk 3, With PRCs	2006/0867
	Serie 2, 3m, Disc 5, No PRC's	2006/0868
	Serie 2, 3m, Disc 6, No PRC's	2006/0869
	Serie 2, 3m, Disc 7, No PRC's	2006/0870
	Serie 2, 3m, Disc 1, With PRCs	2006/0871
	Serie 2, 3m, Disc 2, With PRCs	2006/0872
	Serie 2, 3m, Disc 3, With PRCs	2006/0873
	Serie 2, 3m, Disc 4, With PRCs	2006/0874
3rd sampling	Serie 3, blanco lab, Disc 1, No PRC's	2006/0807
	Serie 3, blanco lab, Disc 2, No PRC's	2006/0808
	Serie 3, blanco lab, Disc 3, With PRC's	2006/0809
	Serie 3, blanco lab, Disc 4, With PRC's	2006/0810
	Serie 3, blanco field, Disc 1, No PRC's	2006/0811
	Serie 3, blanco field, Disc 2, No PRC's	2006/0812
	Serie 3, blanco field, Disc 3, With PRC's	2006/0813
	Serie 3, blanco field, Disc 4, With PRC's	2006/0814
	Serie 3, 3m, Disc 1, No PRC's	2006/0815
	Serie 3, 3m, Disc 2, No PRC's	2006/0816
	Serie 3, 3m, Disc 3, No PRC's	2006/0817
	Serie 3, 3m, Disc 4, No PRC's	2006/0818
	Serie 3, 3m, Disc 5, No PRC's	2006/0819
	Serie 3, 3m, Disc 6, No PRC's	2006/0820
	Serie 3, 3m, Disc 7, No PRC's	2006/0821
	Serie 3, 3m, Disc 8, No PRC's	2006/0822
	Serie 3, 3m, Disc 9, No PRC's	2006/0823
	Serie 3, 3m, Disc 1, With PRC's	2006/0824
	Serie 3, 3m, Disc 2, With PRC's	2006/0825
	Serie 3, 3m, Disc 3, With PRC's	2006/0826
	Serie 3, 3m, Disc 4, With PRC's	2006/0827
	Serie 3, 3m, Disc 5, With PRC's	2006/0828
	Serie 3, 3m, Disc 6, With PRC's	2006/0829
	Serie 3, 3m, Disc 7, With PRC's	2006/0830

Annex 7. Results of Empore disk analysis for total petroleum hydrocarbons, phenols, BTEX and polycyclic aromatic hydrocarbons

Amount of total petroleum hydrocarbons in disks (μg/disk)

	First sampling		Second sampling			Third sampling						
Disk's LIMS no.	2006/0848	2006/0849	2006/0868	2006/0869	2006/0870	2006/0815	2006/0816	2006/0817	2006/0818	2006/0819	2006/0820	2006/0823
	313	985	669	220	780	117	140	113	149	180	138	166

Amount of phenols in disks (ng/disk)

	First sampling				Second sampling		Third sampling		
Disk's LIMS no.:	2006/0850	2006/0851	2006/0852	2006/0859	2006/0873	2006/0874	2006/0824	2006/0825	2006/0826
2-methylphenol	69	<8.2	<8.2	0.5	3.3	4.7	1.8	1.1	1.1
3-methylphenol	17	<4.8	<4.8	<4.8	<8.2	<8.2	0.4	<2.7	<2.7
4-methylphenol	<12.2	<12.2	<12.2	<12.2	0.3	<5.9	<4.9	<4.9	<4.9
2,5-dimethylphenol	65	47	60	67	16	13	<1.7	<1.7	<1.7
2-chlorophenol	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
2,5-dichlorophenol	4	<0.8	6	<0.8	<3.9	<3.9	<2.9	<2.9	<2.9
2,4-dichlorophenol	9	<2.1	<2.1	<2.1	<1.7	0.2	<2.9	<2.9	<2.9
2,4,6-trichlorophenol	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
2,4,5-trichlorophenol	118	14	19	9	21	9	<0.8	<0.8	<0.8

Amount of BTEX in disks (ng/disk)

	First sampling			Second sampling		Third sampling		
Disk's LIMS no.:	2006/0853	2006/0854	2006/0855	2006/0871	2006/0872	2006/0827	2006/0828	2006/0829
benzene	< 70	< 70	< 70	< 70	< 70	<70	<70	<70
toluene	< 80	< 80	< 80	< 80	< 80	<80	<80	<80
ethylbenzene	< 83	< 80	< 80	< 82	< 76	< 79	< 77	< 79
m/p-xylene	< 83	< 80	< 80	< 82	< 76	< 79	< 77	< 79
o-xylene	< 208	< 360	< 343	< 205	< 190	< 196	< 192	< 197
naphthalene	< 83	< 80	< 80	< 82	< 76	< 79	< 77	< 79

Amount of PAHs in disks (ng/disk)

	First sampling		Second sampling			Third sampling						
Disk's LIMS no.	2006/0848	2006/0849	2006/0868	2006/0869	2006/0870	2006/0815	2006/0816	2006/0817	2006/0818	2006/0819	2006/0820	2006/0823
Naphthalene	6.8	16	41	12	68	<1	<1	<1	<1	<1	<1	<1
Acenaphtene	2.5	11	12	3	15	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97	<0.97
Fluorene	36	95	76	29	96	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phenanthrene	6.1	40	44	2.6	53	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77
Anthracene	1.3	2.4	5.4	<1	3.1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	4.4	5.4	6.6	4.7	7.4	<0.93	<0.93	<0.93	<0.93	<0.93	<0.93	<0.93
Pyrene	2.6	7.9	6.7	<0.77	7.5	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77
Benzo(a)anthracene	19	22	14	6	19	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Chrysene	17	24	16	2.4	21	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Benzo(e)pyrene	10	39	28	9.8	34	<1	<1	<1	<1	<1	<1	<1
Benzo(b)fluoranthene	<4.55	22	<4.55	<4.55	5.9	<4.55	<4.55	<4.55	<4.55	<4.55	<4.55	<4.55
Benzo(k)fluoranthene	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72	<1.72
Benzo(a)pyrene	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83	<0.83
Dibenzo(ah)anthracene	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14	<7.14
Benzo(ghi)perylene	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33
Indeno(123cd)pyrene	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33